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Is There a Relationship Between Physician and Facility Volumes of Ambulatory Procedures and Patient Outcomes?

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Abstract: This study explores associations between patient outcomes (7- and 30-day hospitalization and mortality) and healthcare provider (physician and facility) volumes of outpatient colonoscopy, cataract removal, and upper gastrointestinal endoscopy performed in outpatient surgical settings in Florida. Findings indicate that patients treated by high-volume physicians or facilities had lower adjusted odds ratios for hospitalizations and mortality. When physician and facility volume were assessed simultaneously, physician volume accounted for larger effects than facility volume in hospitalization models. When assessing both physician and facility volume together for mortality, facility volume was a stronger predictor of mortality outcomes at 30 days. Further examinations of associations of outpatient physician and facility volumes and patient outcomes are suggested. **Key words:** *outpatient procedures*, *patient outcomes*, *volume*

THE RELATIONSHIP between hospital surgical volume and patient clinical outcome is well documented in the inpatient literature. Patients receiving care in hospitals with higher annual case rates are less likely to die (Begg et al., 2002; Hannan et al., 1998; McGrath et al., 2000; Meyerhardt et al., 2003; Thiemann et al., 1999) and more likely to experience improved outcomes (Hannan et al., 2003; Hughes et al., 1987). Several studies have also established an association between an individual surgeon's volume in the inpatient setting and desirable patient outcomes (Birkmeyer et al., 2003; Chowdhury et al., 2007; Hannan et al., 1991; Harmon et al., 1999; Losina et al., 2004; Phillips et al., 1995). This evidence, linking volume (either hospital, or surgeon, or both) to positive outcomes, spans multiple surgical procedures (Begg et al., 1998; Hannan et al., 1998; Katz et al., 2004), conditions (Druss et al., 2004; Holmboe et al., 2006; Taylor et al., 1997), and age groups (Hannan et al., 1998; Holmboe et al., 2006; McGrath et al., 2000; Phibbs et al., 1996).

Despite the growing inpatient-based literature on the importance of volume for desirable patient outcomes, the relationship

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between volume and ambulatory surgical procedures is less understood. In fact, 2 separate recent systematic reviews of the healthcare literature (Chowdhury et al., 2007; Halm et al., 2002) reported no studies examining the volume-outcome relationship in the outpatient surgical setting. Only 1 study combined inpatient and outpatient data available for endocrine surgeries and discovered a relationship between surgeon volume and positive patient outcomes (Stavrakis et al., 2007). This gap in scientific knowledge is important to address because over the past decade the frequency of ambulatory surgeries has increased by 90% and now accounts for 60% to 70% of all surgeries performed in the United States (MedPAC, 2004).

The *purpose* of this study is to explore the effects of physician and facility volumes on the quality of care in the outpatient setting. Addressing one of the major limitations from the inpatient literature (Halm et al., 2002; Shackley et al., 2000), we examine physician and facility volume simultaneously so that the independent contributions of each can be discerned. Moreover, we study 3 of the most common ambulatory procedures: colonoscopy, cataract removal, and upper gastrointestinal endoscopy. Lastly, we use multiple years of data (1997–2004) and apply a risk adjustment methodology used by the Centers for Medicare & Medicaid Services for outpatient data (Pope et al., 2004).

METHODS

Data sources and study population

Three patient-level databases, representing the 1997 to 2004 time period, were used in the current study. The ambulatory and the inpatient datasets were obtained from the Florida Agency for Health Care Administration, and vital statistics data were obtained from the Florida Department of Health.

The ambulatory discharge dataset contains information on all patients treated in freestanding Ambulatory Surgery Centers (ASCs) and Hospital-based outpatient departments (HOPDs). The dataset available to us includes patient personal identification numbers; demographic characteristics; primary and up to 4 secondary diagnoses as classified by the *International Classification of Diseases, 9th edition, Clinical Modification (ICD-9-CM)*; procedure codes based on Current Procedural Terminology; payer type; unique facility identifiers; operating physician license numbers; and facility type (ie, freestanding ASCs and HOPDs). The inpatient hospital discharge dataset contains information on all hospital admissions to acute care hospitals in Florida. The vital statistics dataset includes the state's death registry.

For this study, we identified all patients older than 18 years who received any of the 3 most common ambulatory procedures performed at ASCs or HOPDs in Florida during the 8-year-study period. We used colonoscopy (n = 1,232,219), cataract removal (n = 2,058,090), and upper gastrointestinal endoscopy (n = 1,273,922) in this study. Together these 3 common procedures represented 33% of all procedures performed in ASC's and HOPD's in Florida during this time period.

Outcome variables

Using patient identifiers, we merged the ambulatory data with the inpatient dataset and vital statistics. Using the inpatient database, we calculated 7- and 30-day hospitalizations. Hospitalizations are important outcome measures in the ambulatory surgical setting because they reflect perioperative complications, add to healthcare cost, and are disruptive for patients (Shnaider & Chung, 2006). We also calculated 7- and 30-day mortality using vital statistics data (Chowdhury et al., 2007). Seven and 30-day outcomes were computed from the date of the ambulatory surgical procedure (Fleisher et al., 2004, 2007; Menachemi et al., 2007; Mezei & Chung, 1999; Warner et al., 1993).

Given that not all hospital admissions and deaths after ambulatory procedures are related to the procedure itself, we excluded outcomes that we deemed unrelated. To do so, before data analysis, the research team of physicians and researchers discussed each inpatient admission diagnosis or mortality category, and with a high degree of agreement, determined unrelated adverse categories for exclusion using *ICD-9-CM* codes (ie, prior admissions or active treatment of any malignancy, human immunodeficiency virus/acquired immunodeficiency syndrome, psychiatric disorders, or deaths from suicides or homicides). The resulting exclusions from this consensus approach accounted for approximately 27% of the total eligible patients. Because of the limitation of administrative data and the exploratory nature of our study, we did not characterize the majority of hospitalizations into either related or unrelated adverse categories associated with outpatient procedures.

Finally, to distinguish between hospitalization and mortality outcomes as well as between different types of procedures, we created an individual data set for each outcome (ie, 7- or 30-day inpatient admission or death) for each of the 3 procedures. We treated each procedure as a separate event performed on that encounter. We also counted adverse outcomes only once in cases where the same patient had multiple encounters for the same procedure. For example, if a patient had a colonoscopy and also a cataract surgery, this would be represented in 2 separate datasets. However, if a patient had 2 cataract removal surgeries and later died within a 30-day period, this would be represented in the same data set as 1 encounter and the mortality outcome counted only once.

Physician and facility-volume variables

We developed 2 types of variables that represented ambulatory surgery provider volume (separately for physicians and outpatient facilities). The first type of volume variable was created by ranking providers into volume categories to observe a gradient relationship between volume and outcomes. We used operating physician license numbers and unique facility identifiers to calculate the total number of procedures that each physician and each outpatient facility performed annually during the study period. We then ranked physicians into low-, medium-, and high-volume categories according to tertiles. We used a similar approach in developing outpatient facility-volume variables. We chose the highest-volume category (greater than the 67th percentile), to be the reference category. The ranking of providers into volume tertiles was done separately for each year during the 1997 to 2004 period.

The second type of volume variable was measured continuously by taking a natural log of the total number of procedures that each physician and each outpatient facility performed annually during the study period. This approach was used to observe potential relationships in studying volume effects and rare adverse events such as mortality.

We used the Florida Agency for Health Care Administration physicians' database to cross check the physicians' operating licenses. In some cases we found that healthcare professionals other than physicians (often ranked in low-volume category) were listed as operating physicians for studied procedures. To eliminate the inclusion of such coding errors in our data, clinicians of any kind with less than 5 cases of a given procedure performed per year were eliminated from that year's analysis. Similarly, outpatient facilities that provided less than 12 procedures per year of a given procedure were excluded from that year's analyses to decrease potential coding errors. Collectively, these exclusions resulted in less than a 2% loss of observations at the patient level.

Patient characteristics and risk adjustment

Patient demographic characteristics included gender, age, race, and insurance type. Age was categorized into 5 groups: 18 to 49 years (the reference group), 50 to 64, 65 to 74, 75 to 84, and 85 years or older. Race was measured as white (the reference group), African-American or black, Hispanic, or other (including unknown). Patient insurance type was categorized as commercial/Preferred Provider Organization (the reference group), Medicare, Medicare Health Maintenance Organization (HMO), Medicaid, Medicaid HMO, HMO, self pay, or other. Lastly, a measure of facility type (eg, ASC or HOPD) was used in the analyses.

We applied severity of illness measures using the diagnostic cost groups/hierarchical condition categories (DCG/HCC) risk-adjustment methodology (DxCG, 2005). Several studies using clinical outcomes have identified the DCG/HCC methodology as having superior predictive properties of patient risk in comparison with alternative risk adjustment methods (ie, the Charlson Index, the Adjusted Clinical Groups and self-reported, risk-adjustment methods) (Meciejewski et al., 2005; Petersen et al., 2005). In addition, the Centers for Medicare & Medicaid Services utilizes the DCG/HCC methodology when calculating adjusted payments amounts (Pope et al., 2004).

We generated a continuous measure of severity (ie, risk scores) that was produced by RiskSmart Stand Alone, V.2.1 software, using the DCG/HCC methodology (DxCG, 2005). We used all available diagnoses (up to 5) codes (*ICD9-CM*) present in the ambulatory discharge data to classify patients into clinically homogeneous and meaningful condition categories (Petersen et al., 2005; Pope et al., 2004). The condition categories were then grouped hierarchically by severity (HCC) and ranked according to their historical cost groups (Petersen et al., 2005; Pope et al., 2004). Each patient with multiple and clinically similar diagnoses was assigned into only 1 group with the highest hierarchy, and the higher group number indicated his/her increasing severity due to comorbid conditions. Also, clinically unrelated disease categories contributed cumulatively in calculation of an individual's total disease burden. The DCG/HCC software translated these HCC groups into relative risk scores representing a continuous measure of severity. Risk scores above the state average score of 1.66 indicated a higher than average severity level for that particular patient. In our study, all outpatient encounters in Florida were used to compute risk scores.

Statistical analysis

We used a pooled, cross-sectional design representing multiple years of data (1997–2004). We separately estimated logistic regression models for each outcome of interest and each method of specifying volume. All models controlled for the same set of patient demographic variables and accounted for patient severity, location of care, clustering of outcomes within providers (ie, either physicians or outpatient facilities depending on the model), insurance type, and time-fixed effects.

Our null hypothesis was that no relationship exists between volume and patient outcomes in the outpatient settings. We examined this hypothesis separately for operating physicians, facilities, and both physician and facilities together. In model 1, we examined differences in patient outcomes by physician-volume tertiles, and separately by a log of the total number of procedures performed by a physician annually. Model 2 examined outcomes by facility-volume tertiles and separately by a log of facility volume. In model 3, we simultaneously examined the effects of physician and facility-volume tertiles, and separately log of physician and log of facility volumes, on patient outcomes. We utilized the tests of restrictions to compare coefficients of physician and facility-volume effects and to determine whether physician or facility effects had greater influence on patient outcomes. Model 3 was warranted because we did not detect any statistically significant interactions or correlations between physician and facility-volume variables for any studied procedures or outcomes. Human subject committee approval was obtained from our university institutional review board.

RESULTS

Table 1 reports the mean numbers of procedures and volume cutoffs that were descriptive of low-, medium-, and high-volume providers. In a given year, a mean of 1111 physicians performed colonoscopies, 769 physicians performed cataract removals, and 973 physicians performed upper gastrointestinal endoscopies each year. In a given year, a mean of 312 facilities provided colonoscopies, 255 facilities provided cataract surgeries, and 305 provided upper gastrointestinal

Table 1. Patient characteristics by physician and facility-volume categories and by ambulatory surgical procedures (1997–2004)*

	Physician-volume category			Facility-volume category		
Colonoscopy	**Low (≤ 99) tertile 1**	**Medium (100–408) tertile 2**	**High (≥ 409) tertile 3**	**Low (≤ 450) tertile 1**	**Medium (451–1,229) tertile 2**	**High (≤ 1230) tertile 3**
Total number of patients (*N*)	58,985	441,103	1,083,296	113,339	411,287	1,058,758
Average number of providers per year (*N*)	358	383	369	104	106	102
Average number of procedures per year (mean, SD)	35 (27)	248 (90)	656 (237)	228 (134)	767 (226)	2,342 (1,041)
ASC, %	29.37	35.94	53.07	28.44	32.49	55.25
Relative risk scores (mean, SD)	1.46 (0.80)	1.41 (0.73)	1.37 (0.69)	1.44 (0.77)	1.42 (0.74)	1.36 (0.69)
Patient age (mean, SD)	61.33 (15.03)	60.56 (1.41)	60.25 (14.54)	60.64 (14.76)	60.51 (14.80)	60.30 (14.58)
Black, %	7.92	7.32	5.62	7.57	7.41	5.55
Hispanic, %	10.22	11.93	7.81	10.42	9.73	8.63
Other or unknown race, %	6.74	6.84	7.60	6.71	7.02	7.56
White, %	75.11	73.91	78.97	72.29	75.84	78.25
Female, %	57.51	59.16	60.59	59.25	59.60	60.35
Payer type, %						
Medicare	40.81	35.76	34.51	37.75	36.18	34.38
Medicare HMO	3.80	4.42	4.02	3.40	4.50	4.06
Medicaid	3.03	1.81	1.07	3.24	1.84	0.96
Medicaid HMO	0.98	0.55	0.46	0.70	0.75	0.43
Commercial/Preferred Provider Organization	32.48	33.00	37.45	33.24	31.38	38.12
HMO	13.31	19.28	19.04	14.85	19.40	19.13
Self pay	1.65	1.28	0.99	2.31	1.35	0.87
Other pay	3.91	3.80	2.46	4.52	4.60	2.06

(*continued*)

Table 1. Patient characteristics by physician and facility-volume categories and by ambulatory surgical procedures (1997–2004)* (*Continued*)

	Physician-volume category			Facility-volume category		
Cataract removal	**Low (≤ 85) tertile 1**	**Medium (86–294) tertile 2**	**High (≥ 295) tertile 3**	**Low (≤ 267) tertile 1**	**Medium (268–965) tertile 2**	**High (≥ 966) tertile 3**
Total number of patients (*N*)	70,395	366,518	1,621,177	79,009	389,016	1,590,065
Average number of providers per year (*N*)	251	263	255	85	86	84
Average number of procedures per year (mean, SD)	36 (24)	176 (59)	800 (903)	120 (77)	568 (207)	2,395 (1952)
ASC, %	53.19	63.8	90.28	28.49	59.11	93.23
Relative risk scores (mean, SD)	1.21 (0.84)	1.16 (0.77)	1.03 (0.64)	1.24 (0.85)	1.15 (0.76)	1.02 (0.64)
Patient age (mean, SD)	72.86 (10.74)	73.63 (9.73)	73.46 (9.03)	72.33 (10.13)	73.30 (9.47)	73.57 (9.11)
Black, %	7.04	4.22	2.69	6.28	4.48	2.62
Hispanic, %	10.83	8.85	5.82	7.77	10.05	5.60
Other or unknown race, %	10.76	12.5	15.9	7.82	12.40	16.14
White, %	71.37	74.43	75.59	78.13	73.07	75.64
Female, %	61.03	60.91	59.76	60.87	60.36	59.88
Payer type, %						
Medicare	65.24	67.71	72.32	65.71	67.90	72.36
Medicare HMO	5.97	6.38	4.46	7.17	8.52	3.85
Medicaid	2.41	1.53	1.46	1.94	1.88	1.39
Medicaid HMO	0.43	0.31	0.21	0.37	0.33	0.21
Commercial/Preferred Provider Organization	11.72	11.07	12.42	13.30	10.87	12.41
HMO	7.99	7.79	5.11	6.55	7.16	5.28
Self pay	1.44	1.39	1.46	1.08	1.23	1.52
Other pay	4.8	3.82	2.56	3.88	2.11	2.98

(*continued*)

Table 1. Patient characteristics by physician and facility-volume categories and by ambulatory surgical procedures (1997–2004)* (*Continued*)

	Physician-volume category			Facility-volume category		
Upper gastrointestinal endoscopy	**Low (≤ 68) tertile 1**	**Medium (69–212) tertile 2**	**High (≥ 213) tertile 3**	**Low (≤ 246) tertile 1**	**Medium (247–606) tertile 2**	**High (≥ 607) tertile 3**
Total number of patients (*N*)	58,657	354,868	860,397	93,301	317,727	862,894
Average number of providers per year (*N*)	315	335	323	101	104	100
Average number of procedures per year (mean, SD)	26 (18)	142 (40)	350 (152)	126 (68)	410 (103)	1,143 (569)
ASC, %	28.48	38.65	51.57	38.62	33.99	52.56
Relative risk scores (mean, SD)	1.66 (1.21)	1.58 (1.09)	1.55 (1.03)	1.57 (1.06)	1.60 (1.10)	1.55 (1.04)
Patient age (mean, SD)	59.52 (16.99)	59.82 (16.70)	59.88 (16.44)	59.52 (16.58)	60.03 (16.63)	59.82 (16.50)
Black, %	8.34	7.21	6.60	8.16	7.00	6.65
Hispanic, %	10.28	10.42	10.79	8.31	11.11	10.75
Other or unknown race, %	6.32	7.41	7.90	7.38	7.03	7.97
White, %	75.06	74.96	74.71	76.15	74.86	74.62
Female, %	60.20	59.34	59.73	60.21	59.59	59.60
Payer type, %						
Medicare	40.79	38.93	39.52	39.94	40.11	39.10
Medicare HMO	3.61	4.25	4.32	3.11	3.91	4.52
Medicaid	4.29	2.26	2.36	4.11	3.14	1.97
Medicaid HMO	1.38	0.84	0.85	0.95	0.97	0.82
Commercial/Preferred Provider Organization	31.00	30.78	31.56	31.08	29.53	32.00
HMO	12.93	17.68	16.98	13.83	16.81	17.39
Self pay	1.96	1.61	1.26	2.61	1.74	1.13
Other pay	4.04	3.66	3.16	4.37	3.79	3.06

ASC indicates Ambulatory Surgery Center; HMO, Health Maintenance Organization.

*The means, SDs, and the ranges were averaged for the number of providers, the number of procedures, and the volume tertile cut offs for each year and over the 8-year period. The remaining information in Table 1 presents data pooled over the 8-year-study period. Also, all the differences between volume categories were statistically significant at the $P < .001$ level.

Table 2. Unadjusted 7- and 30-day hospitalization and mortality rates by physician- and facility-volume categories and by procedures (1997–2004)

	Physician-volume category				Facility-volume category			
	Low	**Medium**	**High**	***P***	**Low**	**Medium**	**High**	***P***
Colonoscopy								
Hospitalization, 7 d, %	0.76	0.62	0.48	.0001	0.66	0.56	0.50	.0001
Hospitalization, 30 d, %	2.43	1.75	1.48	.0001	2.01	1.70	1.50	.0001
Mortality, 7 d, %	0.01	0.01	0.01	.8270	0.01	0.01	0.01	.9182
Mortality, 30 d, %	0.09	0.08	0.08	.4742	0.09	0.09	0.07	.0034
Cataract removal								
Hospitalization, 7 d, %	0.41	0.39	0.32	.0001	0.40	0.35	0.32	.0001
Hospitalization, 30 d, %	1.69	1.46	1.22	.0001	1.52	1.42	1.23	.0001
Mortality, 7 d, %	0.02	0.02	0.01	.3590	0.02	0.02	0.01	.3467
Mortality, 30 d, %	0.11	0.09	0.09	.0415	0.11	0.09	0.08	.0093
Upper gastrointestinal endoscopy								
Hospitalization, 7 d, %	1.20	0.80	0.77	.0001	0.92	0.84	0.77	.0001
Hospitalization, 30 d, %	3.77	2.66	2.52	.0001	3.08	2.81	2.49	.0001
Mortality, 7 d, %	0.06	0.04	0.04	.0151	0.04	0.04	0.04	.5416
Mortality, 30 d, %	0.31	0.23	0.22	.0001	0.26	0.25	0.21	.0001

endoscopies. For colonoscopy, low-volume physicians performed a mean of 35 (range = 5–99), medium-volume physicians performed a mean of 248 (range = 100–408), and high-volume physicians performed a mean of 656 (greater than 409), procedures per year. In the case of facilities, for colonoscopy, low-volume providers performed a mean of 228 (range = 12–450), medium-volume facilities performed a mean of 767 (range = 451–1229), and high-volume facilities performed a mean of 2342 (>1230). Overall, high-volume physicians and facilities were less likely to treat non-white patients or patients with higher severity of illness. However, high-volume physicians and facilities were more likely to treat private-pay patients and to care for them in an ASC setting (Table 1). These patterns were observed across all studied procedures (all *P* values < .0001).

Table 2 displays the unadjusted rates of 7- and 30-day hospitalizations and mortality by provider-volume tertiles. In general, the overall rates of adverse events were low as was expected for outpatient providers. Seven-day and 30-day hospitalization rates did not exceed 1.20%, and 3.77%, respectively (both for upper gastrointestinal endoscopy). Mortality rates were generally lower than one half of 1%. Overall, high-volume providers had lower rates of hospitalizations and mortality. These differences were statistically significant with the exception of 30-day mortality for colonoscopy and most of 7-day mortality for other procedures (Table 2).

Seven- and 30-day hospitalizations

When considering physician volume only (Model 1), an increase in volume was associated with a decrease in hospitalizations among all 3 procedures for both 7-day and 30-day hospitalizations (Table 3). For example, when considering 7-day hospitalizations after colonoscopy, patients treated by low-volume physicians (odds ratio, 1.57; 95% CI, 1.39–1.76) and medium-volume physicians (odds ratio, 1.31; 95% CI, 1.22–1.41) had statistically significantly higher odds of being hospitalized than patients treated by high-volume physicians. When physician volume was measured as a log of the total number of procedures that each physician performed annually,

Table 3. The separate effects of physician volume (model 1) and the facility volume (model 2) on 7- and 30-day hospitalizations by ambulatory surgical procedures (1997–2004)*

		Ambulatory surgical procedure		
		Colonoscopy	**Cataract removal**	**Upper gastrointestinal endoscopy**
7-day hospitalization				
Model 1: Physician volume only	Volume tertile 3 (high)	1.00	1.00	1.00
	Volume tertile 2 (medium)	1.31 (1.22–1.41)†	1.19 (1.10–1.29)†	1.04 (0.98–1.10)
	Volume tertile 1 (low)	1.57 (1.39–1.76)†	1.24 (1.10–1.40)†	1.51 (1.38–1.65)†
Model 1: Log of physician volume only	Odds Ratio and CI	0.82 (0.79–0.85)†	0.90 (0.87–0.93)†	0.89 (0.86–0.93)†
	Coefficient estimate and SE	−0.20 (0.02)†	−0.10 (0.02)†	−0.11 (0.02)†
Model 2: Facility volume only	Volume tertile 3 (high)	1.00	1.00	1.00
	Volume tertile 2 (medium)	1.15 (1.05–1.26)‡	1.10 (1.00–1.20)§	1.08 (1.01–1.15)§
	Volume tertile 1 (low)	1.32 (1.19–1.47)†	1.28 (1.12–1.46)†	1.19 (1.09–1.31)†
Model 2: Log of facility volume only	Odds ratio and CI	0.90 (0.86–0.94)†	0.91 (0.88–0.95)†	0.93 (0.90–0.97)†
	Coefficient estimate and SE	−0.11 (0.02)†	−0.09 (0.02)†	−0.07 (0.02)†
30-day hospitalization				
Model 1: Physician volume only	Volume tertile 3 (high)	1.00	1.00	1.00
	Volume tertile 2 (medium)	1.14 (1.09–1.20)†	1.14 (1.07–1.21)†	1.04 (1.00–1.08)§
	Volume tertile 1 (low)	1.49 (1.38–1.61)†	1.27 (1.19–1.36)†	1.40 (1.32–1.49)†
Model 1: Log of physician volume only	Odds ratio and CI	0.87 (0.84–0.89)†	0.91 (0.88–0.93)†	0.91 (0.88–0.94)†
	Coefficient estimate and SE	−0.14 (0.01)†	−0.10 (0.02)†	−0.09 (0.02)†
Model 2: Facility volume only	Volume tertile 3 (high)	1.00	1.00	1.00
	Volume tertile 2 (medium)	1.10 (1.04–1.16)‡	1.12 (1.04–1.19)‡	1.09 (1.04–1.14)†
	Volume tertile 1 (low)	1.25 (1.17–1.34)†	1.21 (1.10–1.33)†	1.22 (1.14–1.29)†
Model 2: Log of facility volume only	Odds Ratio and CI	0.92 (0.89–0.95)†	0.92 (0.88–0.95)†	0.92 (0.90–0.94)†
	Coefficient estimate and SE	−0.09 (0.02)†	−0.09 (0.02)†	−0.09 (0.01)†

*Models 1 and 2 each controlled for patient severity, gender, race, payer type, and location of care (freestanding ambulatory surgical center or hospital-based outpatient department), time fixed-effects, and clustering of outcomes within providers.

†$P < .001$.

‡$P < .05$.

§$P < .01$.

we observed significant and negative relationships. Similar statistically significant trends were observed when examining 30-day hospitalizations (Table 3).

When considering facility volume only (Model 2), an increase in volume was associated with improved 7- and 30-day hospitalization outcomes across all procedures as well (Table 3). For example, patients treated by low-volume outpatient facilities (colonoscopy: odds ratio, 1.32; 95% CI, 1.19–1.47) and medium-volume facilities (colonoscopy: odds ratio, 1.15; 95% CI, 1.05–1.26) were more likely to have a 7-day hospitalization than patients treated by high-volume facilities. When facility volume was measured as a log of the total number of procedures, we found that as the volume of colonoscopies performed by a facility increased, the patient's likelihood of hospitalization at 7-day decreased. Similarly, 30-day hospitalization rates were significantly higher in low- and medium-volume facilities when compared with high-volume facilities.

When simultaneously testing the effect of physician and facility volume on 7-day and 30-day hospitalization (model 3), the magnitude of effect for physician volume decreased slightly but the overall strength of statistical significance remained consistent in the models representing each of the procedures examined (Table 4). However, the relationship between facility volume and hospitalizations were weakened in both magnitude and significance among all the procedures examined, particularly in the analysis of 7-day hospitalization. These findings were observed in models with physician and facility volumes measured as either categorical or continuous variables.

Lastly, we used the tests of restrictions to determine whether the standard coefficients of physician volume were different from the standard coefficients of the facility volume in model 3. We found that the physician volume effects were statistically significantly greater than the facility-volume effects in colonoscopy and upper gastrointestinal endoscopy procedures for several comparisons (Table 4).

Mortality

When examining mortality at 7 and 30 days, we did not observe any statistically significant gradient relationship between physician- and facility-volume tertiles and patient mortality outcomes. However, statistically significant relationships were observed between log of physician or log of facility volumes and mortality outcomes. Therefore, we present the main findings in terms of log of physician and log of facility volumes in Table 5.

When considering physician volume only (model 1), we found that volume was not associated with mortality outcomes in most procedures at 7 days and 30 days with the exception of the 30-day cataract removal (Table 5). In this case, we observed a negative and significant relationship indicating that as the physician volume increased, the patient's likelihood of morality at 30 days following surgery decreased (Table 5).

When considering facility volume only (model 2), an increase in volume was associated with improved 7- and 30-day mortality outcomes across several procedures (Table 5). For example, the likelihood of patients dying at 7 days and 30 days decreased as the facility volume of cataract removals increased. Similar relationships were observed in the 30-day colonoscopy and upper gastrointestinal endoscopy models (Table 5)

When simultaneously testing the effect of physician and facility volume on 7-day and 30-day mortality outcomes (model 3), the magnitude and significance of effects for physician volume have decreased in the models representing each of the examined procedures (Table 6). The previously significant relationships between facility volume and mortality remained in both magnitude and significance in the 30-day mortality models.

We also used the tests of restrictions to determine whether the standard coefficients of physician volume were different from the standard coefficients of facility volume in model 3. We found that the facility-volume

Table 4. The simultaneous effects of physician and facility volume (model 3) on 7- and 30-day hospitalizations and tests of restrictions comparing differences between physician- or facility-volume coefficients (1997–2004)*

		Ambulatory surgical procedure		
		Colonoscopy	Cataract removal	Upper gastrointestinal endoscopy
7-day hospitalization				
Model 3: Physician volume	Volume tertile 3 (high)	1.00	1.00	1.00
	Volume tertile 2 (medium)	1.28 (1.19–1.38)†	1.17 (1.08–1.27)†	1.02 (0.96–1.08)
	Volume tertile 1 (low)	1.50 (1.33–1.69)†	1.21 (1.08–1.36)‡	1.46 (1.33–1.60)†
Facility volume	Volume tertile 3 (high)	1.00	1.00	1.00
	Volume tertile 2 (medium)	1.11 (1.02–1.20)§	1.07 (0.98–1.16)	1.06 (1.00–1.12)§
	Volume tertile 1 (Low)	1.20 (1.08–1.32)†	1.20 (1.05–1.37)‡	1.13 (1.04–1.22)‡
Tests of restrictions	Physician vs facility tertile 2	5.26§	2.7	0.57
	Physician vs facility tertile 1	6.29§	0.006	14.93†
Model 3: Log of physician volume	Odds ratio and CI	0.83 (0.80–0.86)†	0.92 (0.89–0.95)†	0.90 (0.86–0.95)†
	Coefficient estimate and SE	−0.19 (0.02)†	−0.09 (0.02)†	−0.10 (0.02)†
Log of facility volume	Odds ratio and CI	0.94 (0.90–0.98)‡	0.96 (0.93–1.00)	0.96 (0.90–0.99)§
	Coefficient estimate and SE	−0.06 (0.02)‡	−0.04 (0.02)	−0.04 (0.02)§
Tests of restrictions	Physician vs facility	14.48†	2.86	2.84§
30-day hospitalization				
Model 3: Physician volume	Volume tertile 3 (high)	1.00	1.00	1.00
	Volume tertile 2 (medium)	1.12 (1.07–1.18)†	1.12 (1.06–1.18)†	1.02 (0.97–1.06)
	Volume tertile 1 (low)	1.43 (1.32–1.55)†	1.24 (1.17–1.33)†	1.35 (1.27–1.43)†
Facility volume	Volume tertile 3 (high)	1.00	1.00	1.00
	Volume tertile 2 (medium)	1.08 (1.03–1.13)‡	1.09 (1.02–1.17)‡	1.08 (1.03–1.12)‡
	Volume tertile 1 (low)	1.17 (1.09–1.25)†	1.14 (1.04–1.26)‡	1.16 (1.10–1.23)†
Tests of restrictions	Physician vs facility tertile 2	1.13	0.30	3.54§
	Physician vs facility tertile 1	11.75†	1.81	11.48†
Model 3: Log of physician volume	Odds ratio and CI	0.88 (0.86–0.91)†	0.92 (0.89–0.95)†	0.93 (0.90–0.96)†
	Coefficient estimate and SE	−0.13 (0.01)†	−0.08 (0.01)†	−0.07 (0.02)†
Log of facility volume	Odds ratio and CI	0.94 (0.92–0.97)†	0.96 (0.94–0.99)‡	0.95 (0.92–0.96)†
	Coefficient estimate and SE	−0.06 (0.01)†	−0.04 (0.01)‡	−0.07 (0.01)†
Tests of restrictions	Physician vs facility	9.85‡	5.19 §	0.04

*Model 3 included both categorical measures of physician and facility volume in the same analysis, controlled for patient severity, gender, race, payer type, location of care (freestanding ambulatory surgical center or hospital-based outpatient department), time-fixed effects, and clustering of outcomes within providers and also tested for differences in coefficients comparing physician- and facility-volume tertiles.

†$P < .001$.

‡$P < .01$.

§$P < .05$.

Table 5. The separate effects of physician volume (model 1) and the facility volume (model 2) on 7- and 30-day mortality by ambulatory surgical procedures (1997–2004)*

		Ambulatory surgical procedure		
		Colonoscopy	**Cataract removal**	**Upper gastrointestinal endoscopy**
7-day mortality				
Model 1: Log of physician volume only	Odds ratio and CI	1.02 (0.81–1.27)	0.93 (0.84–1.02)	0.99 (0.86–1.13)
	Coefficient estimate and SE	0.02 (0.11)	−0.08 (0.05)	−0.01 (0.07)
Model 2: Log of facility volume only	Odds ratio and CI	0.99 (0.83–1.19)	0.83 (0.75–0.93)†	0.98 (0.86–1.12)
	Coefficient estimate and SE	−0.01 (0.09)	−0.18 (0.05)†	−0.02 (0.07)
30-day mortality				
Model 1: Log of physician volume only	Odds ratio and CI	0.97 (0.89–1.06)	0.93 (0.88–0.97)‡	0.97 (0.91–1.04)
	Coefficient estimate and SE	−0.03 (0.05)	−0.08 (0.02)‡	−0.03 (0.04)
Model 2: Log of facility volume only	Odds ratio and CI	0.88 (0.80–0.96)	0.90 (0.86–0.95)†	0.90 (0.83–0.96)‡
	Coefficient estimate and SE	−0.13 (0.05)‡	−0.11 (0.02)†	−0.11 (0.04)‡

*Models 1 and 2 each controlled for patient severity, gender, race, payer type, and location of care (freestanding ambulatory surgical center or hospital-based outpatient department), time-fixed effects, and clustering of outcomes within providers.
†$P < .001$.
‡$P < .01$.
§$P < .05$.

effects were statistically significantly different than the physician-volume effects in colonoscopy and upper gastrointestinal endoscopy procedures, indicating that facility volume is a stronger predictor of patient outcomes measured as mortality at 30 days (Table 6).

DISCUSSION

To our knowledge, this is the first study to examine whether an association exists between physician and facility volumes and patient outcomes exclusively for the outpatient setting. Our results show a consistent and dose-responsive pattern demonstrating that, as volume increases, patient outcomes improved for all 3 procedures. Specifically, patients treated by high-volume physicians or in high-volume facilities had lower rates of 7- and 30-day hospitalizations. When physician and facility volumes were assessed simultaneously, physician volume demonstrated stronger effects than facility volume in terms of magnitude and levels of significance. In 2 out of the 3 procedures, the physician volume effects were greater than the outpatient facility-volume effects. As for mortality outcomes, we found more limited physician volume and facility-volume effects. The facility-volume effects were stronger for magnitudes and levels of significance than physician-volume effects in terms of the 30-day mortality outcomes.

Our results are consistent with many studies from the inpatient literature that have found a relationship between procedural volume and patient outcomes. For example, in a recently published comprehensive review (Chowdhury et al., 2007), an inverse relationship between surgeon volume (43 of 58 studies) and hospital volume (94 out of 127 studies) was linked to various inpatient

Table 6. The simultaneous effects of physician and facility volume (model 3) on 7- and 30-day mortality and tests of restrictions comparing differences between physician- or facility-volume coefficients (1997–2004)*

		Ambulatory surgical procedure		
		Colonoscopy	**Cataract removal**	**Upper gastrointestinal endoscopy**
7-day mortality				
Model 3: Log of physician volume	Odds ratio and CI	1.02 (0.81–1.29)	1.00 (0.88–1.14)	0.99 (0.86–1.14)
	Coefficient estimate and SE	0.02 (0.12)	0.003 (0.07)	−0.01 (0.07)
Log of facility volume	Odds ratio and CI	0.99 (0.82–1.19)	0.83 (0.73–0.95)‡	0.98 (0.88–1.10)
	Coefficient estimate and SE	−0.01 (0.09)	−0.18 (0.07)‡	−0.02 (0.06)
Tests of restrictions	Physician vs facility	0.03	2.29	0.01
30-day mortality				
Model 3: Log of physician volume	Odds ratio and CI	1.01 (0.92–1.11)	0.96 (0.91–1.01)	1.01 (0.94–1.08)
	Coefficient estimate and SE	0.01 (0.05)	−0.04 (0.03)	0.01 (0.04)
Log of facility volume	Odds ratio and CI	0.88 (0.81–0.95)†	0.92 (0.87–0.98)‡	0.89 (0.85–0.95)†
	Coefficient estimate and SE	−0.13 (0.04)†	−0.08 (0.03)‡	−0.11 (0.03)†
Tests of restrictions	Physician vs facility	4.43§	0.51	5.19§

*Model 3 included both categorical measures of physician and facility volume in the same analysis, controlled for patient severity, gender, race, payer type, and location of care (freestanding ambulatory surgical center or hospital-based outpatient department), time fixed-effects, and clustering of outcomes within providers, and also tested for differences in coefficients comparing physician- and facility-volume tertiles.

outcomes (Begg et al., 2002; Hannan et al., 1998; McGrath et al., 2000; Meyerhardt et al., 2003; Thiemann et al., 1999). Our outpatient data showed a volume-outcome relationship for both physician and facility volume where physician volume explained a greater percentage of variability in hospitalizations for 2 of the 3 procedures studied. We also found that facility volume was a stronger predictor of patient mortality outcomes. In studying the volume-outcome relationship in outpatient settings, we found that hospitalization outcomes were more sensitive to physician volume and mortality outcomes were more sensitive to facility volume. Future research should study the volume-outcome relationship in the outpatient settings using alternative patient outcomes to validate our findings. Comprehensive medical chart abstraction may assist in development of new patient outcome measures reflective of processes of outpatient care delivery at the physician and/or facility levels.

Our study has several strengths including the use of a comprehensive and longitudinal dataset that employed several widely used outcome measures (Fleisher et al., 2004, 2007; Mezei & Chung, 1999; Warner et al., 1993) and a validated risk-adjustment methodology (Meciejewski et al., 2005; Petersen et al., 2005). Despite these and other strengths, the pooled cross-sectional design we utilized to overcome the relative rarity of the adverse outcomes was nonexperimental and therefore, unable to confirm causality. Even though higher annual procedural volume is believed to sharpen physicians' technical skills and enhance the coordination efficiencies of a care team (Chowdhury et al., 2007; Luft, 1980), an alternative explanation to our observed findings is that facilities and/or physicians that consistently provide high quality care earn more frequent referrals from colleagues and patients (Chowdhury et al., 2007). Future research should employ prospective study designs to establish a better understanding of causality in the outpatient setting.

Other limitations of our study include the use of administrative data for identification of adverse outcomes and risk-adjustment. The use of administrative data for these purposes is suboptimal (Iezzoni, 1994, 1997; Iezzoni et al., 1992, 1994; Romano & Mark, 1994). In the current study, even though we have excluded the most obvious hospitalizations unrelated to outpatient procedures using *ICD-9-CM* codes (eg, all malignancies, psychiatric disorders, and human immunodeficiency virus/acquired immunodeficiency syndrome cases), given the nature of our data, we were unable to separate other unrelated hospitalizations from hospitalizations that occurred due to complications of outpatient procedures. A medical chart abstraction approach, involving panels of experts, is proposed for future studies to clearly identify hospitalizations related to complications of outpatient procedures. Future studies should also use medical charts for more reliable risk adjustment (Halm et al., 2002) because availability of detailed clinical data may resolve issues associated with reporting and coding of secondary diagnoses (that are commonly used for risk-adjustment) by outpatient providers.

We attempted to account for some limitations of administrative data. We used a 7-day measure of hospitalization, which may have helped to minimize the effects of extraneous factors unrelated to outpatient procedures (Fleisher et al., 2004) and it is likely that complications due to outpatient procedures may be occurring in a shorter time span as well. Mortality at 7 days was a rare event for patients undergoing an ambulatory procedure; thus, as standard errors become large, it becomes increasingly difficult to detect statistical differences when they exist.

We were unable to control for patients' income levels or their ability to access needed care. Therefore, we could not directly account for a possibility that indigent patients are being hospitalized or dying regardless of the experience levels of their physicians and facilities. We were able, however, to identify Medicaid and self-pay patients (ie, potentially underinsured and/or uninsured patients). Although payer type variables were not direct measures of patients' income or access to care, these variables may potentially account for some differences in these patients' characteristics. Lastly, our study was conducted in a single state, so future studies from areas representing diverse geographic settings are encouraged.

Even though future research is needed to address the issues of generalizability, causality, and selection of adverse events, healthcare policy makers, payers, providers, managers, and patients should be aware of potential volume effects (by individual physicians and by the overall facility) on patient outcomes. A more immediate and viable approach may be for residency and fellowship programs to expose trainees to a greater number of outpatient procedures to assure an appropriate development of their clinical skills and procedure-specific competencies. Future research also should verify this relationship and potentially determine the precise annual provider caseload needed for assuring improved quality performance.

As we learn more about the relationship between facility and physician volumes and patient outcomes in the outpatient setting, these data may be made publicly available to improve transparency, accountability, and decision-making. This could empower consumers to make informed choices on where to obtain outpatient services, motivate ambulatory care providers and managers to monitor their volume and quality performance, and allow payers and policy makers to encourage improvements in outpatient quality of care.

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